

REMARKS

Claims 1-14, 17, 19-21, 23, and 26-34 are pending in the application. Claim 1 has been amended to overcome the § 112 rejection at paragraph 3 of the Office Action. Reconsideration and withdrawal of the remaining rejections is requested in view of the following remarks.

Claims 1, 2, 26 and 27 describe improved cleaning methods and apparatus involving the use of a heated liquid layer on the surface of the workpiece through which large quantities (at least 90 gph) of ozone diffuse. It is well known that adding heat will increase the reaction kinetics of an oxidizer, such as ozone, thereby speeding up process times. However, it is also well known that the solubility of a gas such as ozone, in a liquid, such as water, decreases with increasing temperature. This characteristic inverse function of gas solubility versus liquid temperature suggests the use of liquid or water at room temperature or lower, in order to increase the level of dissolved ozone in the water. Indeed, various prior art techniques using chilled ozonated water have been proposed. While these techniques can achieve high levels of dissolved ozone, reaction times remain low due to the low temperatures. On the other hand, using water at high temperatures has not been effective, due to the decreasing concentration of ozone in the water as temperature increases.

The claimed methods and apparatus achieve the advantages of both high ozone concentration and high temperature, to provide fast reaction times, by using diffusion, rather than dissolution. While only a low amount of ozone can be dissolved within the heated liquid layer on the surface of the workpiece, large amounts of ozone can diffuse through the layer to react at the workpiece surface, as claimed.

Page 4 of the 10/29/2003 office action asserts that it is obvious to combine references that teach heating a liquid with references that teach treating a workpiece with ozone, as follows:

"This is because using the ozone cause oxide decomposition to occur, and the high the temperature of the ozone cleaning solution, the greater the oxide decomposition effect from the ozone."

While this statement would be reasonable and correct if ozone gas were highly soluble in hot water or liquid, it is well known that the solubility of ozone gas in water decreases rapidly with increasing temperature. Consequently, there is no basis for rejecting the claims over a combination of references that simply teach use of heated liquid and ozone (such as Kashiwase et al, Wada et al, JP '927 or JP '398), because it is not possible to dissolve useful amounts, and certainly not 90 gph, of ozone into the heated liquid.

Claims 1, 2, 26, and 27 all describe introducing ozone at a rate of at least 90 grams per hour (gph), or using an ozone supply system having a capacity of at least 90 gph. This claimed feature is not taught or suggested in any of the cited prior art. Indeed, the 12/23/02 Office Action (paper 13), at paragraph 2, states that "Li et al., Bergman and Matsuoka do not teach the ozone rate as claimed [90 gph]." Applicant submits that the cited references also do not suggest such a feature, or several of the other claimed features.

Li et al., the principle reference, describes a dry cleaning process, and specifically teaches away from employing a wet cleaning process (see cols. 1 and 2),

as described in the claims. For example, Li et al. states that, "One of the drawbacks of wet cleaning is that surface tension can prevent the liquid from penetrating into high aspect ratio features, leaving part of the surface uncleaned" (col. 1, lines 49-51). Accordingly, it is improper to combine Li et al. with references that teach wet cleaning processes, such as Bergman and Matsuoka (see MPEP § 2145(X)(D)(2), stating that, "it is improper to combine references where the references teach away from their combination").

Additionally, Li et al. discloses a surface diffusion layer (col. 4, lines 18-60), which is formed by depositing a vapor on the surface of a wafer (col. 4, line 42). Since Li et al. is a dry-cleaning process, the vapor layer is necessarily extremely thin, with no likelihood of the diffusion layer assisting in maintaining the workpiece at an elevated temperature, as claimed. Moreover, in Li et al., the purpose of the diffusion layer is to inhibit direct reaction of the gas phase with the wafer (col. 4, line 33), in order to eliminate surface roughness (col. 2, lines 38-46).

Thus, the intent of Li et al. runs opposite to the pending claims. The intent of Li et al. is to inhibit direct reaction of the gas phase with the wafer surface (col. 4, line 33), or, in other words, to decrease the mean free path and create a smooth silicon surface, with less pitting or scoring. Accordingly, Li et al., by implication, encourages using relatively low concentrations of ozone, so that ozone is less likely to directly react with the wafer surface. In contrast, claims 1, 2, 26, and 27 provide an increased amount of ozone to directly react at the workpiece surface, via diffusion of ozone through a heated liquid layer, which increases the reaction rate. Thus, Li et al. teaches away from using

a high concentration of ozone, and clearly does not suggest providing ozone at the claimed rate of at least 90 gph.

Matsuoka discloses use of ozone and rotation of the workpieces, as noted by the Examiner at paragraph 2 of the Office Action. However, Matsuoka teaches away from using a heated liquid, as follows:

"A problem with a dry treatment using ozone is that when resists implanted at high doses are treated at relatively high temperatures, pumping, etc., takes place through heat, making some resist residues likely to remain intact." Page 2, lines 56-58.

"Heating the substrates does not permit wet ozone to have well-enough effects, because any thin water film cannot occur even when a wet ozone-containing gas is fed." Page 3, lines 34-35.

Consequently, Matsuoka does not suggest adding ozone at 90 gph, as claimed, since such large quantities of ozone would not dissolve into the cool liquid. Moreover, Matsuoka teaches, in Example 1, an ozone rate of approximately 25 gph (based on the 6 lpm and 55,000 ppm parameters). There is no suggestion in Matsuoka, especially due to the cool temperatures employed, to use a higher rate of ozone. The claims, conversely, recite that ozone is provided at a rate of at least 90 gph, i.e., at least a 350% increase over that which is taught in Matsuoka. It would not have been obvious for one skilled in the art to have increased the ozone rate by such a high percentage, since the claimed increase is so large.

Furthermore, because Matsuoka teaches away from heating, the rate of reaction in Matsuoka is likely much lower than that of the recited claims, which all recite using a heated liquid. Thus, if ozone were introduced at the claimed rate in Matsuoka, much of the ozone would not be used to react with the wafer, and would therefore go to waste. Moreover, the excess ozone would have to be destroyed before release (due to the reactive/corrosive characteristics of ozone), which can be costly and time-consuming. Accordingly, there is no suggestion in Matsuoka to introduce ozone at a high rate, such as the claimed rate of 90 gph.

Bergman teaches uniform etching of a wafer with HF and/or HCl, and makes no mention or suggestion of using high capacity ozone. Thus, Bergman does not teach or suggest introducing ozone into a workpiece-containing environment at the claimed rate of at least 90 grams per hour.

Based on the foregoing, none of the references, alone or in combination, teach or suggest introducing ozone at the claimed rate of at least 90 gph, as recited in claims 1, 2, 26, and 27. Accordingly, a *prima facie* case for obviousness has not been made against these claims (see MPEP §2143.03, stating that "to establish *prima facie* obviousness of a claimed invention, all the claim limitations must be taught or suggested by the prior art").

With respect to claim 28, none of the cited references teach or suggest providing a liquid at a temperature in the range of 55-120° C onto a workpiece, in combination with diffusing ozone through the heated liquid layer. As explained above, there is no basis for rejecting the claims over a combination of references that simply teach use of heated liquid and ozone (such as Kashiwase et al, Wada et al, JP '927 or JP '398),

because it is not possible to dissolve useful amounts of ozone into the heated liquid, and none of these references teach diffusing ozone through a heated liquid layer, as claimed.

In view of the foregoing, it is submitted that the claims are in condition for allowance, and a Notice of Allowance is requested.

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